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ABSTRACT

In this study, a set of behavioral objectives was developed and validated for an undergraduate science program for elementary teachers. The behavioral objectives contain both inquiry and content items which were based on analyses of the COPES, SAPA, IDP, SCIS, ESS, and MINNEMAST elementary school science programs. Some measure of validity of the entire set of behavioral objectives was established by submitting them to a selected group of scientists and educators who participated in the writings of the programs. (Author/CP)

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FINAL REPORT

Project No. 1 G073
Grant No. OEG 7-71-0035 (509)

The Development of Behavioral Objectives for the Undergraduate Science Program for Elementary Teachers March 1973

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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(Regional Research Program)

SE 019 652

ABSTRACT

The Development of Behavioral Objectives for the
Undergraduate Science Program for Elementary Teachers

The need for development of behavioral (criterion referenced) objectives in education has been well documented. A set of behavioral objectives has been developed and validated for the undergraduate science program for elementary teachers for the purposes of: (1) eliminating needless duplication among the science courses required; (2) eliminating the need for specific training in each of the "new" elementary science programs; (3) making the science methods courses for elementary teachers more meaningful and efficient; (4) providing criteria on which better evaluation instruments may be constructed.

The behavioral objectives contain both inquiry and content items which were based on a detailed analysis of the COPES, SAPA, IDP, SCIS, ESS, and MINNEMAST programs. Behavioral objectives for the concepts and inquiry skills occurring in two or more of the programs were formulated by utilizing the methods of McAskan (1970). (Example in appendix.)

Some measure of validity of the entire set of behavioral objectives was established by submitting them to a selected group of scientists and educators who participated in the writing of the programs. The final set of objectives represents a revision based on the ratings and comments of these scientists and educators.

This study provides a set of criterion based objectives from which individuals and institutions may select according to their overall goals. It also provides criteria for the construction of better instruments for evaluating prospective elementary science teachers and the programs utilized to train them.

FINAL REPORT

PROJECT NO. 1 G073
GRANT NO. OEG 7-71-0035 (509)

THE DEVELOPMENT OF BEHAVIORAL OBJECTIVES FOR THE UNDERGRADUATE SCIENCE PROGRAM FOR ELEMENTARY TEACHERS

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March 1973

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education

National Center for Educational Research and Development

Introduction

Problem

STATING OBJECTIVES IS WINDOW DRESSING AND A WASTE OF TIME, IN many instances unless the objectives are stated in behavioral terms. The primary purpose of this study was to develop behavioral objectives for the undergraduate program in science for elementary teachers.

Objectives

Secondary objectives were to: (1) eliminate needless duplication in a new three course sequence in science for elementary teachers which has been developed at Central Missouri State University; (2) eliminate the need for specific training in each of the "new" elementary science programs; (3) make the science methods courses for elementary teachers more appropriate and efficient; (4) to provide criteria to improve the construction of evaluation instruments.

Related Literature

The concept of defining learning in terms of behavior is not new. Dewey has often been quoted as stating that learning is never accomplished until some alteration of behavior has been effected (Drennan, 1970). If this definition is accepted it thus becomes apparent that what an individual knows, what he is able to do, and what he indeed does do under a given set of circumstances may be three entirely different characteristics. There is some experimental evidence (Pierson, 1963) to support this inference.

Although the concept of defining learning in terms of student behavior is an old one it is only within the past 10 or 12 years that significant numbers of psychologists, educational technologists, and academicians have attempted to formulate the concept in operational terms. These people have been engaged in establishing the rules and principles for specifying learning outcomes in terms of observable and measurable student behavior. Some of this work indicates that part of the desirable outcomes of instruction probably cannot be specified in behavioral terms (Atkins, 1968, Samples, 1970, Rath, 1968) however, there are other outcomes that can be so specified (Gagne, 1963, Walbesser, 1963, Kurtz, 1965, Popham, 1968).

There are a number of advantages in specifying objectives in terms of student behavior (Cleaver, 1970, Anderson, 1967, Walbesser, 1968):

1. It forces one to establish priorities for selecting from the "knowledge explosion" and the "multiplicity of pedagogical techniques" those things that are most relevant to obtaining the objectives.

2. It enables the instructor to determine specifically what he will do and thus avoid duplication among courses.

3. It makes possible the establishment of a heirarchy of subject matter (content) and inquiry (process) skills for more effective teaching and learning.

4. It compels a conscientious instructor or researcher to look, at least for correlations and at best for cause-and-effect relationships between learning and instruction.

5. Finally and probably most important, it provides the means by which evaluation can be made more objective and precise; that is one can obtain a concensus as to whether certain behaviors have been exhibited.

"People increasingly want to know what results are likely to be produced by a given level and type of effort, and the schools simply will have to learn how to provide the answers....not just in terms of achievement in broad areas as measured by standarized tests and compared with group norms, but in terms of learning outcomes compared with objectives stated in behavioral terms" (Locke, 1971).

Materials and Methods

Six programs for elementary science were analyzed to determine what science content, and inquiry skills an elementary teacher must possess in order to teach any of the six programs effectively. The programs analyzed were those which have been reviewed in depth and detail by the Far West Laboratory for Educational Research and Development whose, "Criteria for selecting programs for the Elementary Science Information Unit were based on the following questions:

1. Does the program reflect the new trends in science teaching? Does it focus on basic science processes and concepts rather than on learning facts, laws and theories?

2. Do the students work directly and actively with the materials of science, rather than learning about science by reading, listening, and reciting? Does the program create a "laboratory" environment in which students learn by experimenting?

3. Does the program represent a coordinated approach to teaching science, in which the teaching strategies and instructional materials are directly related to learning objectives?

4. Are the materials available for immediate use or will they be available by Fall, 1971?

5. Has the program been thoroughly field tested?

The programs selected for the Elementary Science Information Unit are:

Conceptually Oriented Program in Elementary Science (COPES)
New York University

Elementary Science Study (ESS)
Educational Development Center
McGraw-Hill Book Co.

Inquiry Development Program in Physical Science (IDP)
J. Richard Suchman
Science Research Associates, Inc.

Minnesota Mathematics and Science Teaching Project (MINNEMAST)
Minnemast Center
OMSI Kit, Oregon Museum of Science and Industry: The Judy Company

Science-A Process Approach (S-APA)
Commission on Science Education of the American Association for the Advancement of Science
Xerox Education Group

Science Curriculum Improvement Study (SCIS)
University of California, Berkeley
Rand McNally Publishing Co.

The original plan was to determine the frequency of occurrence of subject matter concepts and inquiry skills included in the six programs. It was found the format of the six programs varied so greatly that no unit existed (i.e. uniform pages, chapters, units etc.) which was common to all. It was thus impossible to say that a concept or inquiry skill appeared any given number of times in a program. Consequently, a note was made only that the concept or inquiry skill was or was not included at least once in the program. If the concept or inquiry skill appeared in more than one of the six programs analyzed, one or more behavioral objectives were constructed for it.

The general procedure used for constructing the objectives was that described by McAshan (See appendix A). Slight modifications of the method were made, namely, no attempt was made to identify the behavioral domain and the desired level of performance was rarely stated in numerical terms.

A list of 249 behavioral objectives for inquiry skills and subject matter concepts were formulated on the basis of the program analyses. A copy of these objectives, (See Appendix B) a letter explaining the project, and a stamped self addressed envelope were sent to the director of each program. Each director was also requested to submit the names of 4 or 5 people whom he regarded as most knowledgeable about his particular program. Only 2 of the 6 directors responded to the letters. A follow up letter (See Appendix C) was mailed approximately 5 weeks later. One director responded to this follow up letter. The 3 directos not responding to either letter were contacted by telephone. One of these three returned the objectives and letters without comment or explanation (ESS). The materails were never returned by the other two directors. (COPES and IDP).

A copy of the objectives and a letter of explanation (See Appendix D) were mailed to persons listed by the responding directors. In order to increase the percent of return, each person not responding to the letter was contacted by telephone where possible. A total of 9 evaluations of the objectives was finally received.

Each objective was rated on a 1 through 5 scale (See Appendix B) where 1 indicated absolutely necessary, 2 indicated highly desirable, 3 indicated desirable, 4 indicated of little importance and, 5 indicated the objective should be omitted. The mean score for each objective was computed. The minimum mean could not be less than 1 or more than 5. The interval 1-5 was divided into five equal parts and interpreted as follows: 1.0-1.7 absolutely necessary, 1.8-2.5 highly desirable, 2.6-3.3 desirable, 3.4-4.1 of little importance, and 4.2-5.0 should be omitted. Since the principal purpose of the study was to formulate a list of objectives common to all the programs analyzed it was rather arbitrarily decided that any objective with an average score of greater than 3.3 be omitted from the revised list.

The original plan was to resubmit the revised list to the same people with instructions to rate the objectives as valid or invalid. In view of the small number of evaluations of the original objectives and the effort required to obtain the responses, it seemed futile to submit the revised list. This part of the plan was therefore abandoned.

Copies of the revised list of objectives along with an abstract of this report will be mailed to the science supervisor or his counterpart in each of the State Departments of Public Instruction. Two copies will be mailed to Instructional Objectives Exchange, a non profit organization, for the dissemination of educational objectives located in Los Angeles. A copy of the revised list of objectives will also be made available to each member of the faculty of the Division of Science and Mathematics of Central Missouri State University.

Results

Table 1
Number and Percent of Objectives Receiving Given Ratings

	(1) Absolutely Necessary Mean 1.0-1.7	(2) Highly Desirable Mean 1.8-2.5	(3) Desirable Mean 2.6-3.3	(4) Of Little Importance Mean 3.4-4.1	(5) Should Be Omitted Mean 4.2-5.0
Number of Items	16	64	94	62	13
Percent of Items	6.4	26.1	37.8	24.9	5.2

Table 1 indicates that 75 or 30.1 percent of the original 249 objectives were regarded by the evaluators as being either of little importance or should be omitted. On the other hand, the evaluators found 80 or 32.5 percent as absolutely necessary or highly desirable for a pre-service elementary science teachers college science program.

The returned objectives were carefully examined for modifications and additions which the evaluators were asked to make. In a few instances, the evaluator did not rate the objective and stated that he did not understand it. In other cases, major changes in wording were made. The total of such changes and non rated objectives was 16. Twelve of these were made by people associated with the SCIS program and 4 by people associated with the S-APA. No completely new objectives were written by any of the evaluators.

The objectives were categorized as being principally concept oriented or principally process oriented. Mathematical skills were included in the latter group. The concept group was further divided into objectives derived from the physical sciences and objectives derived from the biolocical sciences.

Table 2
Percent of Objectives of Each Category Receiving Given Ratings

	(1) Absolutely Necessary Mean 1.0-1.7	(2) Highly Desirable Mean 1.8-2.5	(3) Desirable Mean 2.3-3.3	(4) Of Little Importance Mean 3.4-4.1	(5) Should Be Omitted Mean 4.2-5.0
Physical	3.6%	11.8%	35.5%	37.3%	11.8%
Biological	0.0%	27.5%	52.9%	19.6%	0.0%
Process	13.6%	42.0%	31.8%	12.5%	0.0%

Table 2 indicates that nearly half the physical science objectives were rated of little importance or should be omitted. Approximately one fifth of the biological science objectives were regarded as of little importance but none were recommended for omission or as absolutely necessary. Slightly over 87% of the process objectives were regarded by the evaluators as being worthy of inclusion in the final list. (See Appendix F)

Conclusions

It is possible to develop a set of behavioral objectives for the elementary science teacners college science curriculum which are based on concept and process elements common to several of the "new" elementary science programs. The validity of these objectives is somewhat questionable since it was impossible to obtain the opinions of personnel associated with three of the elementary programs analyzed (IDP, COPES, and ESS).

The revised objectives have been and are useful in deciding what concept and process skills to include in the three course science seqrence and the methods course in elementary science teaching at Central Missouri State University. The objectives should also prove useful to other institutions especially those whose required courses in science are limited to two or three terms.

Recommendations

The revised list of objectives can be used as a point of departure for deciding what concepts and skills to include in the college science courses taken by pre-service elementary teachers. The list of objectives should not be regarded as complete but as a very minimal list. Furthermore, they should be used with care since the validity is somewhat questionable.

In view of the lack of cooperation in attempting to establish the validity of the objectives, it is recommended that the principal investigator of any significant public funded curriculum project be required to cooperate and participate in any bona fide study or evaluation of his curriculum. This should be made a part of the terms of the grant or contract.

Behavioral objectives for the elementary teachers college science curriculum are needed in the affective domain. Such objectives based on pedagogical skills are also needed. The methods used in this study would be adequate for the above tasks provided that a committment on the part of the directors of the curriculums involved could be obtained.

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Appendix A

An Example of McAshans Method for Writing a Behavioral Objective for a Science Concept.

BEHAVIORAL OBJECTIVE GUIDELINES

I. Delegated or Prescribed Need

There is a need for prospective elementary teachers to use the concept of density.

II. Goal Statement (Communication Checks)

A. Behavioral domain: cognitive
B. Learner: prospective elementary teachers
C. Program variable: to use the concept of density

III. Minimum Level Objective

D. To enable elementary teachers to use the concept of density.
E. Given a regular and an irregular object, materials will be requested and the densities of these objects determined.

IV. Desired Level Objective

F. To enable elementary teachers to use the concept of density to the degree that given a regular and an irregular object they will request materails necessary, and perform the operations necessary for determining the density of the objects.
G. To enable elementary teachers to use the concept of density to the degree that 85% of them when given a regular and an irregular object will request materials necessary, and perform the operations necessary for determining the density of the objects.

Appendix A
(continued)

An Example of Mr. Shams Method for Writing a
Behavioral Objective for a Science Process or Inquiry Skill

BEHAVIORAL OBJECTIVE GUIDELINES

I. Delegated or Prescribed Need

There is a need for elementary teachers of science to be able to make inferences from given data.

II. Goal Statement (Communication Checks)

A. Behavioral domain: cognitive
B. Learner: prospective elementary teachers
C. Program variable: ability to make inferences

III. Minimum Level Objective

D. To improve the ability of prospective elementary teachers to make inferences from given data.
E. Write three statements of inferences from given data which do not contradict the data.

IV. Desired Level Objective

F. To improve the ability of prospective elementary teachers to make inferences from given data as evidenced by their writing three statements of inferences from given data which do not contradict the data.
G. To improve the ability of prospective elementary teachers so that 85% of them can write three statements of inferences from given data which do not contradict the data.

Appendix B

Behavioral Objectives Originally Submitted to Evaluators

Instructions: Please circle the number which expresses your opinion of the behavioral objective. (1) absolutely necessary (2) highly desirable (3) desirable (4) of little importance (5) should be omitted

Objective	Rating
1. Given a common object and instructions to make as many different kinds of observations as possible, the student* will write at least five statements of observations which will include: (1) at least one observation made by use of each of the five senses, (2) at least one quantitative observation, and (3) at least one observation which describes some change in the object which occurs spontaneously or which occurs as a result of something the student does to the object.	1 2 3 4 5
2. Given a verbal description, a set of photographs, diagrams, cartoons, drawings, or a physical situation, the student will construct two or more inferences that account for all the relevant observations, and no part of any inference will be in conflict with the observations.	1 2 3 4 5
3. Given a list of statements about a common phenomena, some of which are observations, some of which are inferences, and some of which are irrelevant statements, the student will identify each as observation, inference, or neither.	1 2 3 4 5
4. Given one or more inferences about a common phenomena and the data from which the inferences were derived, the student will alter the inferences when presented with additional data which are in conflict with, or indicate that the original inferences are not satisfactory.	1 2 3 4 5
5. The student will be able to construct a situation to test inferences made by the student about a simple phenomenon.	1 2 3 4 5
6. Given qualitative or quantitative observations on two variables, the student will construct and demonstrate a relationship between the two variables that can be used to make predictions.	1 2 3 4 5
7. The student will write a report or describe verbally an experiment performed by him in terms of purpose, methods, materials, procedures, and results in that order when instructed to report on his experiment.	1 2 3 4 5
8. Given a set of data in tabular or graphical form, the student will construct a prediction about the variables and will revise the prediction on the basis of additional data if such revision is needed.	1 2 3 4 5

*Student as used in these objectives denotes a pre-service elementary teacher.

Objective	Rating
9. Given a phylogenetic key, the student will distinguish between the degrees of relationships among the various groups.	1 2 3 4 5
10. The student will describe a given object as completely as possible using only a given multistage classification system.	1 2 3 4 5
11. The student will construct and demonstrate the use of a multistage classification system given any one of the following: (1) 8-10 household chemicals, (2) 8-10 miscellaneous objects, (3) 8-10 common animals, (4) 8-10 common plants.	1 2 3 4 5
12. The student will state a rule for approximating how many times one number is greater than another, given two numbers written in scientific notation.	1 2 3 4 5
13. Given a set of objects, diagrams, and/or pictures, the student will use the objects to construct the spatial arrangements shown in the diagrams and/or pictures.	1 2 3 4 5
14. Given a set of living and/or non-living three dimensional objects, the student will identify those that are symmetrical and describe all planes of symmetry.	1 2 3 4 5
15. The student will demonstrate all lines of symmetry given a collection of two dimensional paper figures.	1 2 3 4 5
16. Given a protractor, objects, and/or figures containing angles, the student will measure and name the angles.	1 2 3 4 5
17. The student will state and apply rules relating the circumference, diameter, and radius of a circle.	1 2 3 4 5
18. The student will apply a rule relating the linear speed, angular speed, and circumference of a wheel to find either of these quantities when the other two are given.	1 2 3 4 5
19. Given a number line, the student will demonstrate a procedure for finding the sum or difference of any two numbers.	1 2 3 4 5

Objective	Rating
20. Given a group of real numbers, the student will write them in scientific notation and vice versa.	1 2 3 4 5
21. The student will demonstrate procedures for multiplying and dividing very large and very small numbers written in scientific notation.	1 2 3 4 5
22. The student will describe a procedure for determining whether a plant, plant part, animal, or animal part is growing uniformly.	1 2 3 4 5
23. The student will identify and describe the stimulus and response in the behavior of plants and animals.	1 2 3 4 5
24. Given the following two and three dimensional geometric shapes, the student will identify and name them: ellipse, ellipsoid, sphere, sphereoid, circle, square, rectangle, triangle, pyramid, cone, and cylinder.	1 2 3 4 5
25. The student will identify the parts of the body or pictures of them that push and enable various animals to change their positions, and also the medium against which the push is directed.	1 2 3 4 5
26. Given a set of data, the student will construct more than one hypothesis to explain the data. No part of the hypothesis will contradict the data, and all relevant data will be incorporated in the hypothesis.	1 2 3 4 5
27. Given some experimental data and a set of statements concerning the data, the student will identify the statements that are hypotheses and those that are not.	1 2 3 4 5
28. Given a list of hypotheses and/or questions to be tested, the student will name each word in need of operational definition.	1 2 3 4 5
29. Given a hypothesis or question to be tested, the student will name and describe how the dependent variable is to be measured, and name other variables and describe how they are to be held constant.	1 2 3 4 5

Objective	Rating
30. Construct and demonstrate a test of an effect proposed by the student of one independent variable on the behavior of a dependent variable in an investigation.	1 2 3 4 5
31. During an investigation, the student will identify variables and state whether they are controlled or not controlled, and whether each changes or does not change in the same way for all treatments.	1 2 3 4 5
32. The student will construct an operational definition of a term defined by implication from a report of an experiment or by action in an actual experiment.	1 2 3 4 5
33. Given a list of definitions, the student will distinguish between operational and non-operational definitions.	1 2 3 4 5
34. The student will demonstrate procedures for determining the mean, median, mode, and range of a set of measurements.	1 2 3 4 5
35. The student will identify data on a graph, a map, or in a table which supports or does not support a given statement, answer a given question, or form a pattern.	1 2 3 4 5
36. The student will describe how one variable depends on another, given graphs or tables of data of the variables.	1 2 3 4 5
37. The student will distinguish between fundamental and derived units of measure, given a description of measurements taken during an experiment.	1 2 3 4 5
38. Given a set of objects and instruments with which it is impossible to make accurate, direct measurements, the student will demonstrate procedures for making indirect measurements.	1 2 3 4 5
39. The student will demonstrate a procedure for using the field of vision of a microscope for determining a linear dimension of a small object placed in the field.	1 2 3 4 5
40. Given an object which cannot be directly observed, the student will describe the characteristics of the object (appearance and location) on the basis of inferences constructed from a set of observations.	1 2 3 4 5

Objective	Rating
41. The student will construct a revision of a hypothesis given the results of a test of an original hypothesis and additional data obtained from other experiments.	1 2 3 4 5
42. The student will distinguish between CO_2, O_2, and H_2 given small, unlabled samples of these gases and any other materials he may request.	1 2 3 4 5
43. The student will describe in terms of auxin concentration and growth rate a plant stems response to light.	1 2 3 4 5
44. The student will name the parts of the spectrum most conducive to green plant growth and why these are more efficient than other parts.	1 2 3 4 5
45. The student will describe the inferred three dimensional shape of objects pictured in photos on the basis of inferences about the position of the camera, direction of illuminations, and motion of the objects.	1 2 3 4 5
46. The student will state a rule for predicting the angular speed of two connected gears or pulleys, given the angular speed of one and the diameter of both.	1 2 3 4 5
47. The student will describe the location of places and objects in terms of rectangular coordinates.	1 2 3 4 5
48. The student will identify variables that affect the amount of energy transferred to an object in a simple, mechanical system.	1 2 3 4 5
49. The student will order a list of common events according to the flow of energy through a simple system.	1 2 3 4 5
50. The student will identify and describe evidence of energy transfer in simple physical and chemical systems.	1 2 3 4 5
51. The student will identify at least four variables which influence the time it takes cylinders or spheres to roll down inclined planes.	1 2 3 4 5

Objectives	Rating
52. The student will distinguish among objects which are magnets, non-magnets with non-magnetic properties, and non-magnets which have magnetic properties, given a test magnet and several materials in each of the three categories.	1 2 3 4 5
53. Given a pattern of compass direction lines and the geographic orientation, the student will name the poles of the magnet by making inferences from the information.	1 2 3 4 5
54. The student will describe an experiment to identify variables that affect the strength of the magnetic field of a coil of wire in a closed circuit.	1 2 3 4 5
55. The student will state a rule which describes the interaction of a magnet with another magnet, and also materials which are not magnets but which have magnetic properties.	1 2 3 4 5
56. Given a magnet and a small compass, the student will construct a map of the magnetic field.	1 2 3 4 5
57. Given a collection of temporary and permanent magnets, the student will be able to identify the category to which each magnet belongs.	1 2 3 4 5
58. The student will demonstrate changes needed in a given original electrical or mechanical model to make it conform to additional information.	1 2 3 4 5
59. The student will construct an inference which explains observations of simple electrical or mechanical systems whose components are "hidden".	1 2 3 4 5
60. The student will name three forces that produce interactions-at-a-distance.	1 2 3 4 5
61. The student will construct a hypothesis about relationships between changes in organisms and changes in their environment, given data about changes in both.	1 2 3 4 5
62. Given pictures or specimens, the student will order in a chronological sequence stages in the life cycle of a common plant.	1 2 3 4 5

Objective	Rating
63. The student will order pictures or specimens of stages in the life cycle of frogs, fruit flies, meal worms, earthworms, and butterflies.	1 2 3 4 5
64. The student will state a rule which describes a stable population of organisms.	1 2 3 4 5
65. The student will name at least four general factors which limit a population of organisms.	1 2 3 4 5
66. The student will describe a community which includes a human population given a picture or field situation. Description must include identification and names of some competitors, and how humans fit in some food chains.	1 2 3 4 5
67. The student will describe the difference between an ecosystem and a community.	1 2 3 4 5
68. The student will describe conditions necessary for the evaporation and condensation of a liquid in terms of energy and molecular motion.	1 2 3 4 5
69. The student will construct a diagram of the water cycle including some plants and animals.	1 2 3 4 5
70. The student will construct a diagram of the O_2-CO_2 cycle including both physical and biological components.	1 2 3 4 5
71. Given a picture or field situation and data about the particular ecosystem, the student will identify a pollutant or pollutants.	1 2 3 4 5
72. The student will describe the effect of a given common pollutant on the structure of a given biotic community.	1 2 3 4 5
73. The student will identify and describe the function of the embryonic leaf, embryonic root, seed coat, and cotyledon(s) of a germinating seed.	1 2 3 4 5
74. Given data on species, the student will order common seeds according to their germination rates.	1 2 3 4 5

Objectives	Rating
75. The student will identify environmental factors that affect organisms living in a terrarium or aquarium.	1 2 3 4 5
76. The student will identify the food sources of young and mature plants, given pictures or diagrams of the plants and their immediate environment.	1 2 3 4 5
77. Given pictures or a field situation, the student will distinguish between changes produced in the environment by living organisms and changes produced by physical agents.	1 2 3 4 5
78. The student will order a list of events to show the path of carbon, nitrogen, oxygen, and hydrogen from intake into plant to return to the environment.	1 2 3 4 5
79. Given a stocked aquarium or terrarium, the student will construct a diagram of the food webs in each.	1 2 3 4 5
80. The student will name and describe two fundamental types of reproduction.	1 2 3 4 5
81. Given a set of pictures or a field situation, the student will distinguish between communities and populations.	1 2 3 4 5
82. Given a set of pictures or a field situation, the student will identify the green plants of a community as producers, animals as consumers, and molds, bacteria, and yeast as decomposers.	1 2 3 4 5
83. Given pictures or a field situation, the student will identify competitors and name the substance for which the competition exists.	1 2 3 4 5
84. The student will state a rule for determining when a lever system will be in balance.	1 2 3 4 5
85. The student will construct an inference about where weights will have to be placed on a lever system to balance a given amount of weight at a given location.	1 2 3 4 5
86. The student will apply a rule for determining when a lever system is in balance given data containing a number of weights and their distances from a fulcrum.	1 2 3 4 5

Objective	Rating
87. Given a picture, diagram, or field situation which includes a living plant or animal, the student will identify the missing factor or factors necessary for growth and reproduction.	1 2 3 4 5
88. The student will describe the terms minimum range, maximum range, and optimum range with respect to factors that affect the growth of organisms.	1 2 3 4 5
89. The student will name air, light, water, and minerals as essentials for plant growth.	1 2 3 4 5
90. The student will name air, water, minerals, vitamins, carbohydrates, fats, and proteins as essential animal nutrients.	1 2 3 4 5
91. The student will describe an experiment to demonstrate the necessity of oxygen, carbon dioxide, water, or given minerals for continued growth of plants.	1 2 3 4 5
92. Given a combination of solid or solids in a liquid, the student will demonstrate a procedure for determining whether the combination is a solution.	1 2 3 4 5
93. The student will construct an operational definition for a solution.	1 2 3 4 5
94. The student will describe a procedure for determining the relative densities of solutions.	1 2 3 4 5
95. Given two liquids which look alkie, the student will distinguish between them by utilizing any other property or properties other than visual appearance.	1 2 3 4 5
96. The student will identify acids and bases by utilizing bromthymol blue, litmus paper, or phenophthalein.	1 2 3 4 5
97. The student will name the part of a seed which passes the genetic information to the next generation.	1 2 3 4 5
98. The student will name the specific structures in the cell which contain the genetic information.	1 2 3 4 5

Objective	Rating
99. The student will describe the maintenance of a classroom terrarium with respect to light, water, populations, feeding, and cleaning.	1 2 3 4 5
100. The student will be able to identify the following groups of organisms commonly found in terrariums: cacti, lizards, snakes, liverworts, lichens, woodland ferns, newts, toads, tree frogs, salamanders, beetles, venus flytrap, pitcher plants, and sphagnum moss.	1 2 3 4 5
101. The student will demonstrate the preparation and stocking of desert, woodland, and bog terrariums.	1 2 3 4 5
102. The student will describe the maintenance of a classroom aquarium with respect to light, water, populations, feeding, cleaning, and aeration.	1 2 3 4 5
103. The student will demonstrate the preparation and stocking of a freshwater aquarium.	1 2 3 4 5
104. The student will identify the following common aquarium organisms: anacharis, vallisneria, duck weed, snails, daphnia, guppies, and algae.	1 2 3 4 5
105. The student will estimate the area of common environmental surfaces and state the area in metric units within ± 20 percent	1 2 3 4 5
106. The student will estimate the volume of common environmental objects and state the volume in metric units within ± 20 percent.	1 2 3 4 5
107. The student will demonstrate a procedure for determining the weight of an object with a spring scale.	1 2 3 4 5
108. Given a random record of observations, a student will construct a table of data.	1 2 3 4 5
109. The student will describe and demonstrate how to measure the linear speed of a revolving object.	1 2 3 4 5

Objective	Rating
110. The student will demonstrate two procedures for determining whether the amount of liquid remains constant when the liquid is transferred from one container to another.	1 2 3 4 5
111. The student will construct a calibration of a spring or rubber band scale from the elongation when objects of known weight are attached to the spring or rubber band.	1 2 3 4 5
112. Given a map with a scale and a ruler, the student will apply a rule to determine the actual distance between two points.	1 2 3 4 5
113. The student will construct a map, choosing an appropriate scale, given distances, directions, and objects.	1 2 3 4 5
114. The student will demonstrate a procedure for finding the rate of change in volume, weight, length, or area, given the appropriate measurements and times at which they were made.	1 2 3 4 5
115. The student will estimate the lengths of common environmental objects and state the estimated lengths in metric units within ± 20 percent.	1 2 3 4 5
116. The student will distinguish between objects of very similar weights by properly weighing them on a triple beam balance.	1 2 3 4 5
117. The student will demonstrate a procedure for finding and stating the volume of a liquid in standard metric units.	1 2 3 4 5
118. The student will describe in terms of scale, the relationship between the actual dimensions of an object, and those of pictures or models of the object.	1 2 3 4 5
119. Given the appropriate measuring devices and a revolving object, the student will describe the angular speed in terms of revolutions per unit of time, and/or degrees per unit of time.	1 2 3 4 5
120. The student will demonstrate a procedure for finding the length of an object and stating it in millimeters, centimeters, decimeters, and meters.	1 2 3 4 5

Objectives	Rating
121. The student will demonstrate a procedure for finding the area of a plane figure without using a calibrated measuring device.	1 2 3 4 5
122. The student will demonstrate a procedure for ordering a number of containers of various shapes according to increasing volume given only a liquid and the containers to be ordered.	1 2 3 4 5
123. Given the starting point, the melting point, the boiling point, and one point beyond the boiling point, the student will construct a generalized time-temperature curve.	1 2 3 4 5
124. The student will order a solid, a liquid, and a gas (at the same temperature) according to the increasing amount of energy of the particles.	1 2 3 4 5
125. The student will describe in terms of molecular motion the differences between solids, liquids, and gasses.	1 2 3 4 5
126. The student will name the freezing point and boiling point of water and the approximate normal human body temperature in the Celsius, Fahrenheit, and an arbitrary system of temperature measurement.	1 2 3 4 5
127. The student will demonstrate the proper use of Fahrenheit and Celsius thermometers.	1 2 3 4 5
128. Given a number of powder-water systems and crystal-water systems, the student will identify each system as an "energy source" or an "energy receiver."	1 2 3 4 5
129. The student will identify three sources of heat loss from a system in which thermal equilibrium has been attained.	1 2 3 4 5
130. The student will apply a rule for finding the resultant temperature of two or more bodies when they have achieved thermal equilibrium.	1 2 3 4 5
131. The student will apply a rule for finding the temperature in degrees Celsius corresponding to a given Fahrenheit temperature and vice versa.	1 2 3 4 5

Objectives		Rating
132.	The student will identify and name the temperature in degrees Celsius, Fahrenheit, and an arbitrary scale given three diagrams of the thermometers on which are noted the freezing and boiling points of water.	1 2 3 4 5
133.	The student will name three characteristics of a body that affect the amount of heat the body can release or absorb.	1 2 3 4 5
134.	The student will name the criteria used to classify matter as solids, liquids, or gasses.	1 2 3 4 5
135.	The student will identify the source or sources of energy when a change of phase occurs.	1 2 3 4 5
136.	The student will state a rule for determining whether a given solid will float in a given liquid.	1 2 3 4 5
137.	The student will order a list of solids and liquids according to increasing densities, given tables of their volumes and weights.	1 2 3 4 5
138.	The student will request materials needed and demonstrate a procedure for determining the density when given a regular and an irregular object.	1 2 3 4 5
139.	Given that a body will float in a given liquid, the student will state a rule for determining how far the body will sink in the liquid.	1 2 3 4 5
140.	The student will demonstrate a procedure for determining the period of a pendulum by asking for necessary materials and equipment and performing the necessary operations and calculations.	1 2 3 4 5
141.	The student will name at least three variables which affect the period of a pendulum swinging in air.	1 2 3 4 5
142.	Given data containing various periods and lengths of a pendulum, the student will state a rule for predicting the period from the length.	1 2 3 4 5

Objective	Rating
143. The student will distinguish between the frequency and the period of periodic motion phenomena, when given the time and the number of oscillations.	1 2 3 4 5
144. The student will apply a rule for determining the amount of potential energy and the amount of kinetic energy in a freely falling body.	1 2 3 4 5
145. The student will describe two classification systems for energy.	1 2 3 4 5
146. Given a simple chemical or physical system, the student will identify the "energy sources" and the "energy receivers."	1 2 3 4 5
147. The student will describe the Law of Conservation of Energy.	1 2 3 4 5
148. The student will state and apply a rule for determining the gravitational force acting between two bodies.	1 2 3 4 5
149. The student will distinguish between G and g.	1 2 3 4 5
150. The student will state a rule for subtracting vectors by graphical methods.	1 2 3 4 5
151. The student will demonstrate the subtraction of vector quantities by graphical methods.	1 2 3 4 5
152. The student will demonstrate the addition of three or more vector quantities using graphical methods.	1 2 3 4 5
153. The student will state a rule for adding vectors.	1 2 3 4 5
154. The student will name at least three vector quantities and three scalar quantities.	1 2 3 4 5
155. Given a list containing both accurate and inaccurate statements about Newton's third law, the student will distinguish between the two groups.	1 2 3 4 5

Objective	Rating
156. Given a picture or diagram of a tug-of-war or similar situation, the student will identify at least four pairs of action-reaction forces.	1 2 3 4 5
157. The student will construct a sketch of a moving body and identify at least one pair of action-reaction forces.	1 2 3 4 5
158. The student will identify the unbalanced force in a tug-of-war or similar picture or diagram containing action and reaction vectors, in which one side is winning.	1 2 3 4 5
159. Given diagrams or pictures containing force vectors acting on masses, the student will order the pictures according to the increasing or decreasing amount of acceleration of the masses.	1 2 3 4 5
160. The student will identify bodies which will be accelerated given diagrams or pictures with force vectors.	1 2 3 4 5
161. Given any two of the following: net force, mass and acceleration, the student will apply a rule for determining the third.	1 2 3 4 5
162. The student will state a rule for determining the net force acting on a body, given the mass and the acceleration.	1 2 3 4 5
163. Given a diagram showing a block accelerating down an inclined plane, the student will construct a vector diagram showing the unbalanced force.	1 2 3 4 5
164. Given a list of items, some of which have the property of inertia and some which do not, the student will identify and distinguish between the two kinds of items.	1 2 3 4 5
165. The student will state a rule for determining whether the motion of a body will be changed.	1 2 3 4 5
166. Given a physical situation picture, or diagram of a body, the student will construct four force vectors which will not affect the motion of the body.	1 2 3 4 5

Objective		Rating
167.	Given one or more complete flowers or pictures of flowers, the student will identify the following: a. filament, b. anther, c. stamen, d. stigma, e. style, f. ovary, g. pistil, h. petal, i. calyx, j. sepal, and k. corolla.	1 2 3 4 5
168.	Given specimens or pictures of specimens, the student will distinguish between: a. a leaf and a leaflet, b. opposite and alternate leaf arrangements, c. net veined leaves and parallel veined leaves, d. pinnately lobed leaves and palmately lobed leaves.	1 2 3 4 5
169.	Given a small tree seeding, the student will identify the following: a. bark, b. trunk, c. leaf, d. pith, e. veins, f. leaf margin, g. terminal bud, h. auxillary bud, i. petiole, and j. root.	1 2 3 4 5
170.	The student will ask for appropriate materials and construct and demonstrate a device for determining whether an electrical circuit is complete.	1 2 3 4 5
171.	Given appropriate materials and specific schematic diagrams, the student will construct the electrical circuits with lamps, switches, and/or cells in series and/or parallel.	1 2 3 4 5
172.	The student will construct electrical circuits with lamps, switches, and/or cells in series and/or parallel, given only the materials and a statement of the kind of circuit desired.	1 2 3 4 5
173.	Given electrical circuits containing lamps, switches, and cells in series and/or parallel, the student will use conventional symbols to construct a schematic diagram.	1 2 3 4 5
174.	The student will describe a procedure for determining whether an object has changed position.	1 2 3 4 5
175.	The student will state and apply the rule that the speed with which a body changes position is the distance moved per unit of time.	1 2 3 4 5
176.	The student will state and apply a rule for finding the velocity of bodies moving on a straight line in any direction relative to each other and to oneself.	1 2 3 4 5

Objective		Rating
177.	The student will describe changes in position of bodies relative to himself and to that of another observer.	1 2 3 4 5
178.	Given a bar graph, the student will construct a frequency distribution.	1 2 3 4 5
179.	Given bar graphs and data from his own experiments, the student will construct a reasonable predicion.	1 2 3 4 5
180.	The student will identify and name points on a two or three dimensional graph in a conventional manner.	1 2 3 4 5
181.	The student will construct a histogram from a table of frequencies. The histogram must include a title, labels, and scales for both axes, and the zero point must be shown on the ordinate scale.	1 2 3 4 5
182.	Given a point graph, the student will demonstrate a procedure for extrapolating to find unmeasured values.	1 2 3 4 5
183.	The student will order a set of predictions he has made using a point graph from greatest confidence to least confidence.	1 2 3 4 5
184.	Given a point graph, the student will demonstrate a procedure for interpolating to find unmeasured values.	1 2 3 4 5
185.	The student will construct a point graph given a table of data involving two variables. The graph will include a title, labels, and scales for both axes, and a smooth curve if there appears to be a trend in the data. The independent variable must be on the X axis and the dependent variable on the Y axis.	1 2 3 4 5
186.	The student will identify at least four variables which affect the capillary flow rate in a given system.	1 2 3 4 5
187.	The student will describe capillarity in terms of the adhesion and cohesion of molecules.	1 2 3 4 5

Objective		Rating
188.	The student will identify the sources of friction and name friction as the force which opposes motion, given a moving physical system.	1 2 3 4 5
189.	The student will describe the center of mass in terms of the behavior of the mass.	1 2 3 4 5
190.	Given an irregular, essentially two dimensional object, the student will demonstrate a procedure for determining the center of mass.	1 2 3 4 5
191.	The student will state and apply a rule for determining the linear momentum of a body.	1 2 3 4 5
192.	The student will describe the law of conservation of linear momentum utilizing an equation and also verbally.	1 2 3 4 5
193.	The student will demonstrate the use of the equation for the conservation of linear momentum in solving simple linear momentum problems.	1 2 3 4 5
194.	Given the force and the area on which the force is exerted, the student will state a rule for finding the pressure.	1 2 3 4 5
195.	Given any two of the quantities pressure, force, and area, the student will apply a rule for finding the third.	1 2 3 4 5
196.	The student will describe atmospheric pressure in terms of the motion of molecules.	1 2 3 4 5
197.	Given a diagram or a physical situation, the student will distinguish between centripetal and centrifugal force.	1 2 3 4 5
198.	The student will describe the origin of centrifugal forces.	1 2 3 4 5
199.	Given the pressure, temperature, and volume of a gas, the student will apply a rule for finding one of the three quantities when two of them have changed and their values are known.	1 2 3 4 5

Objective		Rating
200.	The student will demonstrate how to make up any given percent solution by volume and by weight.	1 2 3 4 5
201.	The student will construct a diagram illustrating how convex lenses produce enlarged images.	1 2 3 4 5
202.	The student will construct and demonstrate a test for determining the relative viscosity of several different liquids.	1 2 3 4 5
203.	The student will construct a diagram of the O_2-CO_2 cycle which will include plants, animals, and decomposers as well as physical elements.	1 2 3 4 5
204.	The student will request materials and demonstrate a procedure for making an electrical cell.	1 2 3 4 5
205.	The student will describe in terms of voltage, current, and heat the effect of increasing and/or decreasing the resistance in a circuit.	1 2 3 4 5
206.	The student will demonstrate the proper use of a galvanometer.	1 2 3 4 5
207.	The student will describe the conditions necessary for the production of sound.	1 2 3 4 5
208.	The student will name the physical characteristics of waves responsible for pitch and loudness.	1 2 3 4 5
209.	The student will identify the areas of the tongue associated with the sensations of sweet, sour, salt, and bitter.	1 2 3 4 5
210.	Given a balanced chemical equation, the student will describe how it illustrates the law of conservation of mass.	1 2 3 4 5
211.	When shown a physical and/or chemical manipulation of a substance, the student will describe a procedure to determine if the mass remains constant.	1 2 3 4 5

Objective	Rating
212. The student will name at least two ways in which each macroscopic organism in the school terrarium and aquarium changes the environment and at least one organism which the changes affect.	1 2 3 4 5
213. The student will name the color which will be projected on a screen when any two colored filters at a time are placed in front of the lense of a slide projector. (gray or black)	1 2 3 4 5
214. The student will describe how a given colored filter produces its own particular color light.	1 2 3 4 5
215. The student will name the color which will be produced when any two different color pigments are mixed.	1 2 3 4 5
216. The student will describe how a given colored pigment produces its own unique color.	1 2 3 4 5
217. Given an organ or an organ system, the student will describe its macroscopic structure and describe how the structure is adapted for the function it performs.	1 2 3 4 5
218. The student will name three physical environmental factors which affect the germination rate of most seeds.	1 2 3 4 5
219. Given a list of terms, the student will identify factors which would normally tend to increase a population at least temporarily.	1 2 3 4 5
220. Given a number of sets of specimens, pictures, or diagrams, the student will identify the sets with most and least variability.	1 2 3 4 5
221. Given any common laboratory animal, the student will describe a general method or procedure for determining its sex.	1 2 3 4 5
222. The student will state a rule for determining whether a resonance effect will be present in a simple physical system.	1 2 3 4 5

Objective	Rating
223. The student will describe the transfer of energy when a resonance effect is present in a simple physical system.	1 2 3 4 5
224. Given an appropriate physical situation, the student will identify and name a resonance effect.	1 2 3 4 5
225. Given a physical situation or pictures in which the phenomenon of precession is exhibited, the student will name the assumptions and describe precession with vectors.	1 2 3 4 5
226. The student will demonstrate the solutions to simple ratio and proportion problems dealing with physical and biological phenomena.	1 2 3 4 5
227. Given a list of mathematical expressions, the student will identify those that are or may be expressed as ratios.	1 2 3 4 5
228. Given a group of minerals, the student will demonstrate a method for determining the relative hardness of each.	1 2 3 4 5
229. The student will name three general characteristics that may be used to identify crystals.	1 2 3 4 5
230. Given outline sketches of common crystals and a set of specimens, the student will identify the crystals.	1 2 3 4 5
231. Given a set of crystals, the student will request appropriate materials and demonstrate the number of cleavage planes (if any) of each crystal.	1 2 3 4 5
232. Given a collection of materials, some of which contains starch and some which do not, the student will request appropriate materials and distinguish between those which contain starch and those that do not.	1 2 3 4 5
233. Given a list of terms, the student will identify 90 percent of those factors which directly influence the rate of soil erosion by water.	1 2 3 4 5

Objective		Rating
234.	Given diagrams of regular polygons, the student will identify and name the following: triangle, square, pentagon, hexagon, octagon, and decagon.	1 2 3 4 5
235.	Given a narrative account of the weather for a period of days or from observing the weather for a period of days, the student will construct a record of weather conditions utilizing a chart and standard symbols.	1 2 3 4 5
236.	The student will demonstrate the use of a wet bulb-dry bulb hydrometer and chart for determining relative humidity.	1 2 3 4 5
237.	Given an unlabeled diagram and a list of terms, the student will construct a diagram of the life cycle of a flowering plant.	1 2 3 4 5
238.	Given appropriate data, the student will construct an inference about the relationship between temperature and solubility of a solid in a liquid and also the temperature and the solubility of a gas in a liquid.	1 2 3 4 5
239.	The student will request appropriate materials and equipment and demonstrate a procedure for determining true north.	1 2 3 4 5
240.	Given a contour map, the student will identify and name contour lines and elevations.	1 2 3 4 5
241.	Given a ruler and a compass, the student will construct a contour map of a three dimensional object.	1 2 3 4 5
242.	Given two dimensional projections, the student will identify the three dimensional object.	1 2 3 4 5
243.	Given a diagram of a beam of light incident on a plane mirror, the student will construct a diagram of the reflected beam.	1 2 3 4 5
244.	Given a mixture of solids and/or liquids, the student will demonstrate procedures for separating the components of the mixture and for determining the volume and mass of the components.	1 2 3 4 5

Objective		Rating				
245.	Given a field situation or pictures, the student will describe the numbers of living things found in a given area and the observed frequency of various characteristics.	1	2	3	4	5
246.	Given two or more colliding objects, the student will describe the observed changes in terms of speed, weight, and distances moved.	1	2	3	4	5
247.	The student will describe a sequence of procedures for testing for conditions that affect plant growth.	1	2	3	4	5
248.	The student will describe the direction of motion and the rate of change of the motion of plants, parts of plants, animals, or parts of animals which respond to a given stimulus.	1	2	3	4	5
249.	Given a group of rocks and minerals and also a streak plate, vinegar, a magnet, and materials for a simple electrical circuit, the student will distinguish between the various specimens.	1	2	3	4	5

APPENDIX C

July 28, 1972

On June 22 we sent you a list of behavioral objectives and a letter of explanation. We realize that you are a very busy person but we do value your opinions and suggestions. We did not send out form letters nor did we write to large numbers of people. We preferred to concentrate on quality as opposed to quantity.

I am enclosing a xerox copy of my previous letter, the list of behavioral objectives, and stamped self addressed envelope. If you have not already done so, I do hope you will find time to avaluate the behavioral objectives. Projects of this kind never get off the ground without the aid and consideration of people like you.

Sincerely,

Charles O. Hinerman, Ph.D.
Asst. Prof. of Science Educ.

COH: ljw

Enclosure

Dear (name of Program Director)

Dr. (name of Program Director) was kind enough to give us his opinion of the enclosed materials and gave us your name as a person who is also an expert on (name of Program). We would like to draw upon your expertise for a project which we believe will further the general goals of (Program) in particular and science education in general.

We are currently working on a U.S.O.E. small grant project whose purpose is to develop a set of behavioral objectives for the elementary teachers entire undergraduate science program. These objectives include subject matter concepts and inquiry skills and do not include pedagogical skills or philosophical orientation at this time.

In order to determine what minimum concepts and inquiry skills in science the prospective elementary teacher should possess, we have very carefully analyzed the following programs to ascertain which science concepts and inquiry skills were included: COPES, SCIS, ESS, S-APA (AAAS), MINNEMAST, and IDP. If a topic was unique to a single program, it was not included.

The enclosed set of behavioral objectives was formulated based on the above analysis. In order to establish the validity of the objectives, we would like to request a few minutes from your busy schedule. Will you please evaluate the objectives in the light of the subject matter concepts and inquiry skills a teacher would need in order to teach (name of Program). If there are other subject matter concepts or inquiry skills which you feel are very essential to (name of Program) would you please jot them on the reverse side of any of the pages?

Your cooperation will be sincerely appreciated.

Sincerely,

Charles O. Hinerman, Ph.D.
Asst. Prof. of Science Educ.

COH/ljw

Enclosure

Appendix E

Mean Rating of Each Objective by Evaluators

1.0-1.7 absolutely necessary, 1.8-2.5 highly desirable, 2.6-3.3 desirable, 3.4-4.1 of little importance, 4.2-5.0 should be omitted

Objective	Mean Rating by Evaluators
1. Given a common object and instructions to make as many different kinds of observations as possible, the student* will write at least five statements of observations which will include: (1) at least one observation made by use of each of the five senses, (2) at least one quantitative observation, and (3) at least one observation which describes some change in the object which occurs spontaneously or which occurs as a result of something the student does to the object.	2.00
2. Given a verbal description, a set of photographs, diagrams, cartoons, drawings, or a physical situation, the student will construct two or more inferences that account for all the relevant observations, and no part of any inference will be in conflict with the observations.	1.80
3. Given a list of statements about a common phenomena, some of which are observations, some of which are inferences and some of which are irrelevant statements, the student will identify each as observation, inference, or neither.	1.60
4. Given one or more inferences about a common phenomena and the data from which the inferences were derived, the student will alter the inferences when presented with additional data which are in conflict with, or indicate that the original inferences are not satisfactory.	1.60
5. The student will be able to construct a situation to test inferences made by the student about a simple phenomenon.	1.33
6. Given qualitative or quantitative observations on two variables, the student will construct and demonstrate a relationship between the two variables that can be used to make predictions.	2.00
7. The student will write a report or describe verbally an experiment performed by him in terms of purpose, methods, materials, procedures, and results in that order when instructed to report on his experiment.	2.40
8. Given a set of data in tabular or graphical form, the student will construct a prediction about the variables and will revise the prediction on the basis of additional data if such revision is needed.	1.90

*Student as used in these objectives denotes a pre-service elementary teacher.

Objective	Mean Rating by Evaluators
9. Given a phylogenetic key, the student will distinguish between the degrees of relationships among the various groups.	3.60
10. The student will describe a given object as completely as possible using only a given multistage classification system.	3.30
11. The student will construct and demonstrate the use of a multistage classification system given any one of the following: (1) 8-10 household chemicals, (2) 8-10 miscellaneous objects, (3) 8-10 common animals, (4) 8-10 common plants.	2.00
12. The student will state a rule for approximating how many times one number is greater than another, given two numbers written in scientific notation.	3.40
13. Given a set of objects, diagrams, and/or pictures, the student will use the objects to construct the spatial arrangements shown in the diagrams and/or pictures.	2.10
14. Given a set of living and/or non-living three dimensional objects, the student will identify those that are symmetrical and describe all planes of symmetry.	2.40
15. The student will demonstrate all lines of symmetry given a collection of two dimensional paper figures.	2.40
16. Given a protractor, objects, and/or figures containing angles, the student will measure and name the angles.	2.90
17. The student will state and apply rules relating the circumference, diameter, and radius of a circle.	3.30
18. The student will apply a rule relating the linear speed, angular speed, and circumference of a wheel to find either of these quantities when the other two are given.	3.50
19. Given a number line, the student will demonstrate a procedure for finding the sum or difference of any two numbers.	2.80

Objective	Mean Rating by Evaluators
20. Given a group of real numbers, the student will write them in scientific notation and vice versa.	3.20
21. The student will demonstrate procedures for multiplying and dividing very large and very small numbers written in scientific notation.	3.60
22. The student will describe a procedure for determining whether a plant, plant part, animal, or animal part is growing uniformly.	2.44
23. The student will identify and describe the stimulus and response in the behavior of plants and animals.	2.80
24. Given the following two and three dimensional geometric shapes, the student will identify and name them: ellipse, ellipsoid, sphere, sphereoid, circle, square, rectangle, triangle, pyramid, cone, and cylinder.	2.80
25. The student will identify the parts of the body or pictures of them that push and enable various animals to change their positions, and also the medium against which the push is directed.	3.20
26. Given a set of data, the student will construct more than one hypothesis to explain the data. No part of the hypothesis will contradict the data, and all relevant data will be incorporated in the hypothesis.	1.88
27. Given some experimental data and a set of statements concerning the data, the student will identify the statements that are hypotheses and those that are not.	1.90
28. Given a list of hypotheses and/or questions to be tested, the student will name each word in need of operational definition.	2.30
29. Given a hypothesis or question to be tested, the student will name and describe how the dependent variable is to be measured, and name other variables and describe how they are to be held constant.	1.60

Objective	Mean Rating by Evaluators
30. Construct and demonstrate a test of an effect proposed by the student of one independent variable on the behavior of a dependent variable in an investigation.	1.90
31. During an investigation, the student will identify variables and state whether they are controlled or not controlled, and whether each changes or does not change in the same way for all treatments.	1.50
32. The student will construct an operational definition of a term defined by implication from a report of an experiment or by action in an actual experiment.	2.80
33. Given a list of definitions, the student will distinguish between operational and non-operational definitions.	2.40
34. The student will demonstrate procedures for determining the mean, median, mode, and range of a set of measurements.	2.80
35. The student will identify data on a graph, a map, or in a table which supports or does not support a given statement, answer a given question, or form a pattern.	1.80
36. The student will describe how one variable depends on another, given graphs or tables of data of the variables.	2.00
37. The student will distinguish between fundamental and derived units of measure, given a description of measurements taken during an experiment.	2.80
38. Given a set of objects and instruments with which it is impossible to make accurate, direct measurements, the student will demonstrate procedures for making indirect measurements.	2.66
39. The student will demonstrate a procedure for using the field of vision of a microscope for determining a linear dimension of a small object placed in the field.	2.80
40. Given an object which cannot be directly observed, the student will describe the characteristics of the object (appearance and location) on the basis of inferences constructed from a set of observations	1.90

Objective	Mean Rating by Evaluators
41. The student will conduct a revision of a hypothesis given the results of a test of an original hypothesis and additional data obtained from other experiments.	1.50
42. The student will distinguish between CO_2, O_2, and H_2 given small, unlabled samples of these gases and any other materials he may request.	3.30
43. The student will describe in terms of auxin concentration and growth rate a plant stems response to light.	3.60
44. The student will name the parts of the spectrum most conducive to green plant growth and describe why these are more efficient than other parts.	3.70
45. The student will describe the inferred three dimensional shape of objects pictured in photos on the basis of inferences about the position of the camera, direction of illuminations, and motion.	3.00
46. The student will state a rule for predicting the angular speed of two connected gears or pulleys, given the angular speed of one and the diameter of both.	3.40
47. The student will describe the location of places and objects in terms of rectangular coordinates.	1.40
48. The student will identify variables that affect the amount of energy transferred to an object in a simple, mechanical system.	2.40
49. The student will order a list of common events according to the flow of energy through a simple system.	2.40
50. The student will identify and describe evidence of energy transfer in simple physical and chemical systems.	1.70
51. The student will identify at least four variables which influence the time it takes cylinders or spheres to roll down inclined planes.	2.80

Objective	Mean Rating by Evaluators
52. The student will distinguish among objects which are magnets, non-magnets with non-magnetic properties, and non-magnets which have magnetic properties, given a test magnet and several materials in each of the three categories.	2.40
53. Given a pattern of compass direction lines and the geographic orientation, the student will name the poles of the magnet by making inferences from the information.	2.50
54. The student will describe an experiment to identify variables that affect the strength of the magnetic field of a coil of wire in a closed circuit.	3.00
55. The student will state a rule which describes the interaction of a magnet with another magnet, and also materials which are not magnets but which have magnetic properties.	2.60
56. Given a magnet and a small compass, the student will construct a map of the magnetic field.	2.40
57. Given a collection of temporary and permanent magnets, the student will be able to identify the category to which each magnet belongs.	2.70
58. The student will demonstrate changes needed in a given original electrical or mechanical model to make it conform to additional information.	2.60
59. The student will construct an inference which explains observations of simple electrical or mechanical systems whose components are "hidden."	1.70
60. The student will name three forces that produce interactions-at-a-distance.	3.00
61. The student will construct a hypothesis about relationships between changes in organisms and changes in their environment, given data about changes in both.	1.50
62. Given pictures or specimens, the student will order in a chronological sequence stages in the life cycle of a common plant.	1.90
63. The student will order pictures or specimens of stages in the life cycle of frogs, fruit flies, meal worms, earthworms, and butterfiles.	

Objective	Mean Rating by Evaluators
64. The student will state a rule which describes a stable population of organisms.	2.70
65. The student will name at least four general factors which limit a population of organisms.	2.40
66. The student will describe a community which includes a human population given a picture or field situation. Description must include identification and names of some competitors, and how humans fit in some food chains.	2.44
67. The student will describe the difference between an ecosystem and a community.	2.60
68. The student will describe conditions necessary for the evaporation and condensation of a liquid in terms of energy and molecular motion.	3.40
69. The student will construct a diagram of the water cycle including some plants and animals.	2.70
70. The student will construct a diagram of the O_2-CO_2 cycle including both physical and biological components.	3.00
71. Given a picture or field situation and data about the particular ecosystem, the student will identify a pollutant or pollutants.	2.60
72. The student will describe the effect of a given common pollutant on the structure of a given biotic community.	2.50
73. The student will identify and describe the function of the embryonic leaf, embryonic root, seed coat, and cotyledon(s) of a germinating seed.	3.10
74. Given data on species, the student will order common seeds according to their germination rates.	2.90
75. The student will identify environmental factors that affect organisms living in a terraruim or aquarium.	1.90
76. Given pictures or a field situation, the student will distinguish between changes produced in the environment by living organisms and changes produced by physical agents.	2.20

Objective	Mean Rating by Evaluators
77. The student will identify the food sources of young and mature plants, given pictures or diagrams of the plants and their immediate environment.	2.60
78. The student will order a list of events to show the path of carbon, nitrogen, oxygen, and hydrogen from intake into plant to return to the environment.	3.40
79. Given a stocked aquarium or terrarium, the student will construct a diagram of the food webs in each.	2.10
80. The student will name and describe two fundamental types of reproduction.	2.80
81. Given a set of pictures or a field situation, the student will distinguish between communities and populations.	2.60
82. Given a set of pictures or a field situation, the student will identify the green plants of a community as producers, animals as consumers, and molds, bacteria, and yeast as decomposers.	2.20
83. Given pictures or a field situation, the student will identify competitors and name the substance for which the competition exists.	2.70
84. The student will state a rule for determining when a lever system will be in balance.	3.20
85. The student will construct an inference about where weights will have to be placed on a lever system to balance a given amount of weight at a given location.	2.90
86. The student will apply a rule for determining when a lever system is in balance given data containing a number of weights and their distances from a fulcrum.	3.40
87. Given a picture, diagram, or field situation which includes a living plant or animal, the student will identify the missing factor or factors necessary for growth and reproduction.	2.80
88. The student will describe the terms minimum range, maximum range, and optimum range with respect to factors that affect the growth of organisms.	2.80

Objective	Mean Rating by Evaluators
89. The student will name air, light, water, and minerals as essentials for plant growth.	2.50
90. The student will name air, water, minerals, vitamins, carbohydrates, fats, and proteins as essential animal nutrients.	2.90
91. The student will describe an experiment to demonstrate the necessity of oxygen, carbon dioxide, water, or given minerals for continued growth of plants.	2.10
92. Given a combination of solid or solids in a liquid, the student will demonstrate a procedure for determing whether the combination is a solution.	2.10
93. The student will construct an operational definition for a solution.	2.20
94. The student will describe a procedure for determining the relative densities of solutions.	2.80
95. Given two liquids which look alike, the student will distinguish between them by utilizing any other property or properties other than visual appearance.	2.20
96. The student will identify acids and bases by utilizing bromthymol blue, litmus paper, or phenophthalein.	2.30
97. The student will name the part of a seed which passes the genetic information to the next generation.	3.30
98. The student will name the specific structures in the cell which contain the genetic information.	3.60
99. The student will describe the maintenance of a classroom terrarium with respect to light, water, populations, feeding, and cleaning.	2.20
100. The student will be able to identify the following groups of organisms commonly found in terrariums: cacti, lizards, snakes, liverworts, lichens, woodland ferns, newts, toads, tree frogs, salamanders, beetles, venus flytrap, pitcher plants, and sphagnum moss.	3.30

Objective	Mean Rating by Evaluators
101. The student will demonstrate the preparation and stocking of desert, woodland, and bog terrariums.	2.70
102. The student will describe the maintenance of a classroom aquarium with respect to light, water, populations, feeding, cleaning, and aeration.	1.90
103. The student will demonstrate the preparation and stocking of a freshwater aquarium.	1.90
104. The student will identify the following common aquarium organisms: anacharis, vallisneria, duck weed, snails, daphnia, guppies, and algae.	2.80
105. The student will estimate the area of common environmental surfaces and state the area in metric units within ± 20 percent.	3.40
106. The student will estimate the volume of common environmental objects and state the volume in metric units within ± 20 percent.	3.40
107. The student will demonstrate a procedure for determining the weight of an object with a spring scale.	2.40
108. Given a random record of observations, a student will construct a table of data.	2.00
109. The student will describe and demonstrate how to measure the linear speed of a revolving object.	3.30
110. The student will demonstrate two procedures for determining whether the amount of liquid remains constant when the liquid is transferred from one container to another.	2.50
111. The student will construct a calibration of a spring or rubber band scale from the elongation when objects of known weight are attached to the spring or rubber band.	2.10
112. Given a map with a scale and a ruler, the student will apply a rule to determine the actual distance between two points.	2.00
113. The student will construct a map, choosing an appropriate scale, given distances, directions, and objects.	1.60

Objective	Mean Rating by Evaluators
114. The student will demonstrate a procedure for finding the rate of change in volume, weight, length, or area, given the appropriate measurements and times at which they were made.	2.40
115. The student will estimate the lengths of common environmental objects and state the estimated lengths in metric units within ± 20 percent.	2.70
116. The student will distinguish between objects of very similar weights by properly weighing them on a triple beam balance.	2.90
117. The student will demonstrate a procedure for finding and stating the volume of a liquid in standard metric units.	2.80
118. The student will describe in terms of scale, the relationship between the actual dimensions of an object, and those of pictures or models of the object.	2.70
119. Given the appropriate measuring devices and a revolving object, the student will describe the angular speed in terms of revolutions per unit of time, and/or degrees per unit of time.	3.10
120. The student will demonstrate a procedure for finding the length of an object and stating it in millimeters, centimeters, decimeters, and meters.	2.40
121. The student will demonstrate a procedure for finding the area of a plane figure without using a calibrated measuring device.	2.66
122. The student will demonstrate a procedure for ordering a number of containers of various shapes according to increasing volume given only a liquid and the containers to be ordered.	2.20
123. Given the starting point, the melting point, the boiling point, and one point beyond the boiling point, the student will construct a generalized time-temperature curve.	3.22
124. The student will order a solid, a liquid, and a gas (at the same temperature) according to the increasing amount of energy of the particles.	3.50

Objective	Mean Rating by Evaluators
125. The student will describe in terms of molecular motion the differences between solids, liquids, and gasses.	3.80
126. The student will name the freezing point and boiling point of water and the approximate normal human body temperature in the Celsius, Fahrenheit, and an arbitrary system of termperature measurement.	3.40
127. The student will demonstrate the proper use of Fahrenheit and Celsius thermometers.	2.00
128. Given a number of powder-water systems and crystal-water systems, the student will identify each system as an "energy source" or an "energy receiver."	2.40
129. The student will identify three sources of heat loss from a system in which thermal equilibrium has been attained.	3.00
130. The student will apply a rule for finding the resultant temperature of two or more bodies when they have achieved thermal equilibrium.	3.10
131. The student will apply a rule for finding the temperature in degrees Celsius corresponding to a given Fahrenheit temperature and vice versa.	3.20
132. The student will identify and name the temperature in degrees Celsius, Fahrenheit, and an arbitrary scale given three diagrams of the thermometers on which are noted the freezing and boiling points of water.	3.40
133. The student will name three characteristics of a body that affect the amount of heat the body can release or absorb.	3.40
134. The student will name the criteria used to classify matter as solids, liquids, or gasses.	2.80
135. The student will identify the source or sources of energy when a change of phase occurs.	2.50
136. The student will state a rule for determining whether a given solid will float in a given liquid.	2.80

Objective	Mean Rating by Evaluators
137. The student will order a list of solids and liquids according to increasing densities, given tables of their volumes and weights.	3.10
138. The student will request materials needed and demonstrate a procedure for determining the density when given a regular and an irregular object.	2.44
139. Given that a body will float in a given liquid, the student will state a rule for determining how far the body will sink in the liquid.	3.20
140. The student will name at least three variables which affect the period of a pendulum swinging in air.	3.10
141. The student will demonstrate a procedure for determining the period of a pendulum by asking for necessary materials and equipment and performing the necessary operations and calculations.	2.60
142. Given data containing various periods and lengths of a pendulum, the student will state a rule for predicting the period from the length.	3.00
143. The student will distinguish between the frequency and the period of periodic motion phenomena, when given the time and the number of oscillations.	3.60
144. The student will apply a rule for determining the amount of potential energy and the amount of kinetic energy in a freely falling body.	3.70
145. The student will describe two classification systems for energy.	3.55
146. Given a simple chemical or physical system, the student will identify the "energy sources" and the "energy receivers."	2.50
147. The student will describe the Law of Conservation of Energy.	3.40
148. The student will state and apply a rule for determining the gravitational force acting between two bodies.	4.00

Objective	Mean Rating by Evaluators
149. The student will distinguish between G and g.	4.30
150. The student will state a rule for subtracting vectors by graphical methods.	3.80
151. The student will demonstrate the subtraction of vector quantities by graphical methods.	3.40
152. The student will demonstrate the addition of three or more vector quantities using graphical methods.	3.70
153. The student will state a rule for adding vectors.	3.80
154. The student will name at least three vector quantities and three scalar quantities.	3.90
155. Given a list containing both accurate and inaccurate statements about Newton's third law, the student will distinguish between the two groups.	3.90
156. Given a picture or diagram of a tug-of-war or similar situation, the student will identify at least four pairs of action-reaction forces.	3.10
157. The student will construct a sketch of a moving body and identify at least one pair of action-reaction forces.	3.10
158. The student will identify the unbalanced force in a tug-of-war or similar picture or diagram containing action and reaction vectors, in which one side is winning.	3.10
159. Given diagrams or pictures containing force vectors acting on masses, the student will order the pictures according to the increasing or decreasing amount of acceleration of the masses.	3.70
160. The student will identify bodies which will be accelerated given diagrams or pictures with force vectors.	3.60
161. Given any two of the following; net force, mass and acceleration, the student will apply a rule for determining the third.	4.38

Objective	Mean Rating by Evaluators
162. The student will state a rule for determining the net force acting on a body, given the mass and the acceleration.	4.20
163. Given a diagram showing a block accelerating down an inclined plane, the student will construct a vector diagram showing the unbalanced force.	3.70
164. Given a list of items, some of which have the property of inertia and some which do not, the student will identify and distinguish between the two kinds of items.	3.88
165. The student will state a rule for determining whether the motion of a body will be changed.	3.55
166. Given a physical situation, picture, or a diagram of a body, the student will construct four force vectors which will not affect the motion of the body.	3.80
167. Given one or more complete flowers or pictures of flowers, the student will identify the following: a. filament, b. anther, c. stamen, d. stigma, e. style, f. ovary, g. pistil, h. petal, i. calyx, j. sepal, and k. corolla.	4.10
168. Given specimens or pictures of specimens, the student will distinguish between: a. a leaf and a leaflet, b. opposite and alternate leaf arrangements, c. net veined leaves and parallel veined leaves, d. pinnately lobed leaves and palmately lobed leaves.	3.90
169. Given a small tree seeding, the student will identify the following: a. bark, b. trunk, c. leaf, d. pith, e. veins, f. leaf margin, g. terminal bud, h. axillary bud, i. petiole, and j. root.	3.70
170. The student will ask for appropriate materials and construct and demonstrate a device for determining whether an electrical circuit is complete.	1.60
171. Given appropriate materials and specific schematic diagrams, the student will construct the electrical circuits with lamps, switches, and/or cells in series and/or parallel.	2.00
172. The student will construct electrical circuits with lamps, switches, and/or cells in series and/or parallel, given only the materials and a statement of the kind of circuit desired.	2.40

Objective		Mean Rating by Evaluators
173.	Given electrical circuits containing lamps, switches, and cells in series and/or parallel, the student will use conventional symbols to construct a schematic diagram.	2.90
174.	The student will describe a procedure for determining whether an object has changed position.	2.20
175.	The student will state and apply the rule that the speed with which a body changes position is the distance moved per unit of time.	3.00
176.	The student will state and apply a rule for finding the velocity of bodies moving on a straight line in any direction relative to each other and to oneself.	3.30
177.	The student will describe changes in position of bodies relative to himself and to that of another observer.	1.70
178.	Given a bar graph, the student will construct a frequency distribution.	2.00
179.	Given bar graphs and data from his own experiments, the student will construct a reasonable prediction.	1.60
180.	The student will identify and name points on a two or three dimensional graph in a conventional manner.	1.70
181.	The student will construct a histogram from a table of frequencies. The histogram must include a title, labels, and scales for both axes, and the zero point must be shown on the ordinate scale.	1.50
182.	Given a point graph, the student will demonstrate a procedure for extrapolating to find unmeasured values.	2.20
183.	The student will order a set of predictions he has made using a point graph from greatest confidence to least confidence.	2.40
184.	Given a point graph, the student will demonstrate a procedure for interpolating to find unmeasured values.	2.30

Objective	Mean Rating by Evaluators
185. The student will construct a point graph given a table of data involving two variables. The graph will include a title, labels, and scales for both axes, and a smooth curve if there appears to be a trend in the data. The independent variable must be on the X axis and the dependent variable on the Y axis.	2.44
186. The student will identify at least four variables which affect the capillary flow rate in a given system.	4.10
187. The student will describe capillarity in terms of the adhesion and cohesion of molecules.	4.20
188. The student will identify the sources of friction and name friction as the force which opposes motion, given a moving physical system.	3.70
189. The student will describe the center of mass in terms of the behavior of the mass.	4.10
190. Given an irregular, essentially two dimensional object, the student will demonstrate a procedure for determining the center of mass.	3.80
191. The student will state and apply a rule for determining the linear momentum of a body.	4.20
192. The student will describe the law of conservation of linear momentum utilizing an equation and also verbally.	4.20
193. The student will demonstrate the use of the equation for the conservation of linear momentum in solving simple linear momentum problems.	4.20
194. Given the force and the area on which the force is exerted, the student will state a rule for finding the pressure.	3.60
195. Given any two of the quantities pressure, force, and area, the student will apply a rule for finding the third.	3.60
196. The student will describe atmospheric pressure in terms of the motion of molecules.	3.90

Objective	Mean Rating by Evaluators
197. Given a diagram or a physical situation, the student will distinguish between centripetal and centrifugal force.	4.20
198. The student will describe the origin of centrifugal forces.	4.00
199. Given the pressure, temperature, and volume of a gas, the student will apply a rule for finding one of the three quantities when two of them have changed and their values are known.	4.00
200. The student will demonstrate how to make up any given percent solution by volume and by weight.	3.40
201. The student will construct a diagram illustrating how convex lenses produce enlarged images.	3.30
202. The student will construct and demonstrate a test for determing the relative viscosity of several different liquids.	2.70
203. The student will construct a diagram of the O_2-CO_2 cycle which will include plants, animals, and decomposers as well as physical elements.	2.80
204. The student will request materials and demonstrate a procedure for making an electrical cell.	3.20
205. The student will describe in terms of voltage, current, and heat the effect of increasing and/or decreasing the resistance in a circuit.	3.50
206. The student will demonstrate the proper use of a galvanometer.	3.70
207. The student will describe the conditions necessary for the production of sound.	3.20
208. The student will name the physical characteristics of waves responsible for pitch and loudness.	3.60
209. The student will identify the areas of the tongue associated with the sensations of sweet, sour, salt, and bitter.	3.66
210. Given a balanced chemical equation, the student will describe how it illustrates the law of conservation of mass.	4.10

Objective	Mean Rating by Evaluators
211. When shown a physical and/or chemical manipulation of a substance, the student will describe a procedure to determine if the mass remains constant.	4.20
212. The student will name at least two ways in which each macroscopic organism in the school terrarium and aquarium changes the environment and at least one organism which the changes affect.	2.60
213. The student will name the color which will be projected on a screen when any two colored filters at a time are placed in front of the lense of a slide projector.	3.80
214. The student will describe how a given colored filter produces its own particular color light.	3.90
215. The student will name the color which will be produced when any two different color pigments are mixed.	3.20
216. The student will describe how a given colored pigment produces its own unique color.	3.77
217. Given an organ or an organ system, the student will describe its macroscopic structure and describe how the structure is adapted for the function it performs.	3.70
218. The student will name three physical environmental factors which affect the germination rate of most seeds.	2.40
219. Given a list of terms, the student will identify factors which would normally tend to increase a population at least temporarily.	2.60
220. Given a number of sets of specimens, pictures, or diagrams, the student will identify the sets with most and least variability.	2.40
221. Given any common laboratory animal, the student will describe a general method or procedure for determining its sex.	3.80
222. The student will state a rule for determining whether a resonance effect will be present in a simple physical system.	4.10

Objective	Mean Rating by Evaluators
223. The student will describe the transfer of energy when a resonance effect is present in a simple physical system.	4.20
224. Given an appropriate physical situation, the student will identify and name a resonance effect.	4.30
225. Given a physical situation or pictures in which the phenomenon of precession is exhibited, the student will name the assumptions and describe precession with vectors.	4.30
226. The student will demonstrate the solutions to simple ratio and proportion problems dealing with physical and biological phenomena.	2.40
227. Given a list of mathematical expressions, the student will identify those that are or may be expressed as ratios.	3.00
228. Given a group of minerals, the student will demonstrate a method for determining the relative hardness of each.	2.90
229. The student will name three general characteristics that may be used to identify crystals.	3.20
230. Given outline sketches of common crystals and a set of specimens, the student will identify the crystals.	3.50
231. Given a set of crystals, the student will request appropriate materials and demonstrate the number of cleavage planes (if any) of each crystal.	3.90
232. Given a collection of materials, some of which contains starch and some which do not, the student will request appropriate materials and distinguish between those which contain starch and those that do not.	3.20
233. Given a list of terms, the student will identify 90 percent of those factors which directly influence the rate of soil erosion by water.	3.20
234. Given diagrams of regular polygons, the student will identify and name the following: triangle, square, pentagon, hexagon, octagon, and decagon.	2.70

Objective	Mean Rating by Evaluators
235. Given a narrative account of the weather for a period of days or from observing the weather for a period of days, the student will construct a record of weather conditions utilizing a chart and standard symbols.	2.60
236. The student will demonstrate the use of a wet bulb-dry bulb hydrometer and chart for determining relative humidity.	3.00
237. Given an unlabeled diagram and a list of terms, the student will construct a diagram of the life cycle of a flowering plant.	3.20
238. Given appropriate data, the student will construct an inference about the relationship between temperature and soluability of a solid in a liquid and also the temperature and the soluability of a gas in a liquid.	3.20
239. The student will request appropriate materials and equipment and demonstrate a procedure for determining true north.	3.20
240. Given a contour map, the student will identify and name contour lines and elevations.	3.20
241. Given a ruler and a compass, the student will construct a contour map of a three dimensional object.	3.40
242. Given two dimensional projections, the student will identify the three dimensional object used to produce the projections.	2.80
243. Given a diagram of a beam of light incident on a plane mirror, the student will construct a diagram of the reflected beam.	3.30
244. Given a mixture of solids and/or liquids, the student will demonstrate procedures for separating the components of the mixture and for determining the volume and mass of the components.	3.00
245. Given a field situation or pictures, the student will describe the numbers of living things found in a given area and the observed frequency of various characteristics.	2.60

Objective	Mean Rating by Evaluators
246. Given two or more colliding objects, the student will describe the observed changes in terms of speed, weight, and distances moved.	3.30
247. The student will describe a sequence of procedures for testing for conditions that affect plant growth.	2.20
248. The student will describe the direction of motion and the rate of change of the motion of plants, parts of plants, animals, or parts of animals which respond to a given stimulus.	2.80
249. Given a group of rocks and minerals and also a streak plate, vinegar, a magnet, and materials for a simple electrical circuit, the student will distinguish between the various specimens.	3.33

Appendix F
Behavioral Objectives for Pre Service Elementary Teachers College
Science Programs

1.0-1.7 absolutely necessary, 1.8-2.5 highly desirable, 2.6-3.3 desirable, 3.4-4.1 of little importance, 4.2-5.0 should be omitted.

Objective	Mean Rating by Evaluators
1. Given a common object and instructions to make as many different kinds of observations as possible, the student* will write at least five statements of observations which will include: (1) at least one observation made by use of each of the five senses, (2) at least one quantitative observation, and (3) at least one observation which describes some change in the object which occurs spontaneously or which occurs as a result of something the student does to the object.	2.00
2. Given a verbal description, a set of photographs, diagrams, cartoons, drawings, or a physical situation, the student will construct two or more inferences that account for all the relevant observations, and no part of any inference will be in conflict with the observations.	1.80
3. Given a list of statements about a common phenomena, some of which are observations, some of which are inferences, and some of which are irrelevant statements, the student will identify each as observation, inference, or neither.	1.60
4. Given one or more inferences about a common phenomena and the data from which the inferences were derived, the student will alter the inferences when presented with additional data which are in conflict with, or indicate that the original inferences are not satisfactory.	1.60
5. The student will be able to construct a situation to test inferences made by the student about a simple phenomenon.	1.33
6. Given qualitative or quantitative observations on two variables, the student will construct and demonstrate a relationship between the two variables that can be used to make predictions.	2.00
7. The student will write a report or describe verbally an experiment performed by him in terms of purpose, methods, materials, procedures, and results in that order when instructed to report on his experiment.	2.40

*Student as used in these objectives denotes a pre-service elementary teacher.

Objective	Mean Rating by Evaluators
8. Given a set of data in tabular or graphical form, the student will construct a prediction about the variables and will revise the prediction on the basis of additional data if such revision is needed.	1.90
9. The student will describe a given object as completely as possible using only a given multistage classification system.	3.30
10. The student will construct and demonstrate the use of a multistage classification system given any one of the following: (1) 8-10 household chemicals, (2) 8-10 miscellaneous objects, (3) 8-10 common animals, (4) 8-10 common plants.	2.00
11. Given a set of objects, diagrams, and/or pictures, the student will use the objects to construct the spatial arrangements shown in the diagrams and/or pictures.	2.10
12. Given a set of living and/or non-living three dimensional objects, the student will identify those that are symmetrical and describe all planes of symmetry.	2.40
13. The student will demonstrate all lines of symmetry given a collection of two dimensional paper figures.	2.40
14. Given a protractor, objects, and/or figures containing angles, the student will measure and name the angles.	2.90
15. The student will state and apply rules relating the circumference, diameter, and radius of a circle.	3.30
16. Given a number line, the student will demonstrate a procedure for finding the sum or difference of any two numbers.	2.80
17. Given a group of real numbers, the student will write them in scientific notation and vice versa.	3.20
18. The student will describe a procedure for determining whether a plant, plant part, animal, or animal part is growing uniformly.	2.44

Objective	Mean Rating by Evaluators
19. The student will identify and describe the stimulus and response in the behavior of plants and animals.	2.80
20. Given the following two and three dimensional geometric shapes, the student will identify and name them: ellipse, ellipsoid, sphere, spheroid, circle, square, rectangle, triangle, pyramid, cone, and cylinder.	2.80
21. The student will identify the parts of the body or pictures of them that push and enable various animals to change their positions, and also the medium against which the push is directed.	3.20
22. Given a set of data, the student will construct more than one hypothesis to explain the data. No part of the hypothesis will contradict the data, and all relevant data will be incorporated in the hypothesis.	1.88
23. Given some experimental data and a set of statements concerning the data, the student will identify the statements that are hypotheses and those that are not.	1.90
24. Given a list of hypotheses and/or questions to be tested, the student will name each word in need of operational definition.	2.30
25. Given a hypothesis or question to be tested, the student will name and describe how the dependent variable is to be measured, and name other variables and describe how they are to be held constant.	1.60
26. Construct and demonstrate a test of an effect proposed by the student of one independent variable on the behavior of a dependent variable in an investigation.	1.90
27. During an investigation, the student will identify variables and state whether they are controlled or not controlled, and whether each changes or does not change in the same way for all treatments.	1.50

Objective	Mean Rating by Evaluators
28. The student will construct an operational definition of a term defined by implication from a report of an experiment or by action in an actual experiment.	2.80
29. Given a list of definitions, the student will distinguish between operational and non-operational definitions.	2.40
30. The student will demonstrate procedures for determining the mean, median, mode, and range of a set of measurements.	2.80
31. The student will identify data on a graph, a map, or in a table which supports or does not support a given statement, answer a given question, or form a pattern.	1.80
32. The student will describe how one variable depends on another, given graphs or tables of data of the variables.	2.00
33. The student will distinguish between fundamental and derived units of measure, given a description of measurements taken during an experiment.	2.80
34. Given a set of objects and instruments with which it is impossible to make accurate, direct measurements, the student will demonstrate procedures for making indirect measurements.	2.66
35. The student will demonstrate a procedure for using the field of vision of a microscope for determining a linear dimension of a small object placed in the field.	2.80
36. Given an object which cannot be directly observed, the student will describe the characteristics of the object (appearance and location) on the basis of inferences constructed from a set of observations.	1.90
37. The student will construct a revision of a hypothesis given the results of a test of an original hypothesis and additional data obtained from other experiments.	1.50
38. The student will distinguish between CO_2, O_2, and H_2 given small, unlabled samples of these gases and any other materials he may request.	3.30

Objective	Mean Rating by Evaluators
39. The student will describe the inferred three dimensional shape of objects pictured in photos on the basis of inferences about the position of the camera, direction of illuminations, and motion of the objects.	3.00
40. The student will describe the location of places and objects in terms of rectangular coordinates.	1.40
41. The student will identify variables that affect the amount of energy transferred to an object in a simple, mechanical system.	2.40
42. The student will order a list of common events according to the flow of energy through a simple system.	2.40
43. The student will identify and describe evidence of energy transfer in simple physical and chemical systems.	1.70
44. The student will identify at least four variables which influence the time it takes cylinders or spheres to roll down inclined planes.	2.80
45. The student will distinguish among objects which are magnets, non-magnets with non-magnetic properties, and non-magnets which have magnetic properties, given a test magnet and several materials in each of the three categories.	2.40
46. Given a pattern of compass direction lines and the geographic orientation, the student will name the poles of the magnet by making inferences from the information.	2.50
47. The student will describe an experiment to identify variables that affect the strength of the magnetic field of a coil of wire in a closed circuit.	3.00
48. The student will state a rule which describes the interaction of a magnet with another magnet, and also materials which are not magets but which have magnetic properties.	2.60

Objective	Mean Rating by Evaluators
49. Given a magnet and a small compass, the student will construct a map of the magnetic field.	2.40
50. Given a collection of temporary and permanent magnets, the student will be able to identify the category to which each magnet belongs.	2.70
51. The student will demonstrate changes needed in a given original electrical or mechanical model to make it conform to additional information.	2.60
52. The student will construct an inference which explains observations of simple electrical or mechanical systems whose components are "hidden."	1.70
53. The student will name three forces that produce interactions-at-a-distance.	3.00
54. The student will construct a hypothesis about relationships between changes in organisms and changes in their environment, given data about changes in both.	1.50
55. Given pictures or specimens, the student will order in a chronological sequence stages in the life cycle of a common plant.	1.90
56. The student will order pictures or specimens of stages in the life cycle of frogs, fruit flies, meal worms, earthworms, and butterflies.	1.80
57. The student will state a rule which describes a stable population of organisms.	2.70
58. The student will name at least four general factors which limit a population of organisms.	2.40
59. The student will describe a community which includes a human population given a picture or field situation. Description must include identification and name of some competitors, and how humans fit in some food chains.	2.44
60. The student will construct a diagram of the water cycle including some plants and animals.	2.70
61. The student will describe the difference between an ecosystem and a community.	2.60

Objective	Mean Rating by Evaluators
62. The student will construct a diagram of the O_2-CO_2 cycle including both physical and biological components.	3.00
63. Given a picture or field situation and data about the particular ecosystem, the student will identify a pollutant or pollutants.	2.60
64. The student will describe the effect of a given common pollutant on the structure of a given biotic community.	2.50
65. The student will identify and describe the function of the embryonic leaf, embryonic root, seed coat, and cotyledon(s) of a germinating seed.	3.10
66. Given data on species, the student will order common seeds according to their germination rates.	2.90
67. The student will identify environmental factors that affect organisms living in a terraruim or aquarium.	1.90
68. Given pictures or a field situation, the student will distinguish between changes produced in the environment by living organisms and changes produced by physical agents.	2.20
69. The student will identify the food sources of young and mature plants, given pictures or diagrams of the plants and their immediate environment.	2.60
70. Given a stocked aquarium or terrarium, the student will construct a diagram of the food webs in each.	2.10
71. The student will name and describe two fundamental types of reproduction.	2.80
72. Given a set of pictures or a field situation, the student will distinguish between communities and populations.	2.60
73. Given a set of pictures or a field situation, the student will identify the green plants of a community as producers, animals as consumers, and molds, bacteria, and yeast as decomposers.	2.20

Objective	Mean Rating by Evlauators
74. Given pictures or a field situation, the student will identify competitors and name the substance for which the competition exists.	2.70
75. The student will state a rule for determining when a lever system will be in balance.	3.20
76. The student will construct an inference about where weights will have to be placed on a lever system to balance a given amount of weight at a given location.	2.90
77. Given a picture, diagram, or field situation which includes a living plant or animal, the student will identify the missing factor or factors necessary for growth and reproduction.	2.80
78. The student will describe the terms minimum range, maximum range, and optimum range with respect to factors that affect the growth of organisms.	2.80
79. The student will name air, light, water, and minerals as essentials for plant growth.	2.50
80. The student will name air, water, minerals, vitamins, carbohydrates, fats, and proteins as essential animals nutrients.	2.90
81. The student will describe an experiment to demonstrate the necessity of oxygen, carbon dioxide, water, or given minerals for continued growth of plants.	2.10
82. Given a combination of solid or solids in a liquid, the student will demonstrate a procedure for determining whether the combination is a solution.	2.10
83. The student will construct an operational definition for a solution.	2.20
84. The student will describe a procedure for determinimg the relative densities of solutions.	2.80
85. Given two liquids which look alike, the student will distinguish between them by utilizing any other property or properties other than visual appearance.	2.20
86. The student will identify acids and bases by utilizing bromthymol blue, litmus paper, or phenophthalein.	2.30

Objective	Mean Rating by Evaluators
87. The student will name the part of a seed which passes the genetic information to the next generation.	3.30
88. The student will describe the maintenance of a classroom terrarium with respect to light, water, populations, feeding, and cleaning.	2.20
89. The student will be able to identify the following groups of organisms commonly found in terrariums: cacti, lizards, snakes, liverworts, lichens, woodland ferns, newts, toads, tree frogs, salamanders, beetles, venus flytrap, pitcher plants, and sphagnum moss.	3.30
90. The student will demonstrate the preparation and stocking of desert, woodland, and bog terrariums.	2.70
91. The student will describe the maintenance of a classroom aquarium with respect to light, water, populations, feeding, cleaning, and aeration.	1.90
92. The student will demonstrate the preparation and stocking of a freshwater aquarium.	1.90
93. The student will identify the following common aquarium organisms: anacharis, vallisneria, duck weed, snails, daphnia, guppies, and algae.	2.30
94. The student will demonstrate a procedure for determining the weight of an object with a spring scale.	2.40
95. Given a random record of observations, a student will construct a table of data.	2.00
96. The student will describe and demonstrate how to measure the linear speed of a revolving object.	3.30
97. The student will demonstrate two procedures for determining whether the amount of liquid remains constant when the liquid is transferred from one container to another.	2.50
98. The student will construct a calibration of a spring or rubber band scale from the elongation when objects of known weight are attached to the spring or rubber band.	2.10

Objective	Mean Rating by Evaluators
99. Given a map with a scale and a ruler, the student will apply a rule to determine the actual distance between two points.	2.00
100. The student will construct a map, choosing an appropriate scale, given distances, directions, and objects.	1.60
101. The student will demonstrate a procedure for finding the rate of change in volume, weight, length, or area, given the appropriate measurements and times at which they were made.	2.40
102. The student will estimate the lengths of common environmental objects and state the estimated lengths in metric units within ± 20 percent.	2.70
103. The student will distinguish between objects of very similar weights by properly weighing them on a triple beam balance.	2.90
104. The student will demonstrate a procedure for finding and stating the volume of a liquid in standard metric units.	2.80
105. The student will describe in terms of scale, the relationship between the actual dimensions of an object, and those of pictures or models of the object.	2.70
106. Given the appropriate measuring devices and a revolving object, the student will describe the angular speed in terms of revolutions per unit of time, and/or degrees per unit of time.	3.10
107. The student will demonstrate a procedure for finding the length of an object and stating it in millimeters, centimeters, decimeters, and meters.	2.40
108. The student will demonstrate a procedure for finding the area of a plane figure without using a calibrated measuring device.	2.66
109. The student will demonstrate a procedure for ordering a number of containers of various shapes according to increasing volume given only a liquid and the containers to be ordered.	2.20

Objective	Mean Rating by Evaluators
110. Given the starting point, the melting point, the boiling point, and one point beyond the boiling point, the student will construct a generalized time-temperature curve.	3.22
111. The student will demonstrate the proper use of Fahrenheit and Celsius thermometers.	2.00
112. Given a number of powder-water systems and crystal-water systems, the student will identify each system as an "energy source" or an "energy receiver."	2.40
113. The student will identify three sources of heat loss from a system in which thermal equilibrium has been attained.	3.00
114. The student will apply a rule for finding the resultant temperature of two or more bodies when they have achieved thermal equilibrium.	3.10
115. The student will apply a rule for finding the temperature in degrees Celsius corresponding to a given Fahrenheit temperature and vice versa.	3.20
116. The student will name the criteria used to classify matter as solids, liquids, or gasses.	2.80
117. The student will identify the source or sources of energy when a change of phase occurs.	2.50
118. The student will state a rule for determining whether a given solid will float in a given liquid.	2.80
119. The student will order a list of solids and liquids according to increasing densities, given tables of their volumes and weights.	3.10
120. The student will request materials needed and demonstrate a procedure for determining the density when given a regular and an irregular object.	2.44
121. Given that a body will float in a given liquid, the student will state a rule for determining how far the body will sink in the liquid.	3.20
122. The student will demonstrate a procedure for determining the period of a pendulum by asking for necessary materials and equipment and performing the necessary operations and calculations.	2.60

Objective	Mean Rating by Evaluators
123. The student will name at least three variables which affect the period of a pendulum swinging in air.	3.10
124. Given data containing various periods and lengths of a pendulum, the student will state a rule for predicting the period from the length.	3.00
125. Given a simple chemical or physical system, the student will identify the "energy sources" and the "energy receivers."	2.50
126. Given a picture or diagram of a tug-of-war or similar situation, the student will identify at least four pairs of action-reaction forces.	3.10
127. The student will construct a sketch of a moving body and identify at least one pair of action-reaction forces.	3.10
128. The student will identify the unbalanced force in a tug-of-war or similar picture or diagram containing action and reaction vectors, in which one side is winning.	3.10
129. The student will ask for appropriate materials and construct and demonstrate a device for determining whether an electrical circuit is complete.	1.60
130. Given appropriate materials and specific schematic diagrams, the student will construct the electrical circuits with lamps, switches, and/or cells in series and/or parallel.	2.00
131. The student will construct electrical circuits with lamps, switches, and/or cells in series and/or parallel, given only the materials and a statement of the kind of circuit desired.	2.40
132. Given electrical circuits containing lamps, switches, and cells in series and/or parallel, the student will use conventional symbols to construct a schematic diagram.	2.90
133. The student will describe a procedure for determining whether an object has changed position.	2.20

Objective	Mean Rating by Evaluators
134. The student will state and apply the rule that the speed with which a body changes position is the distance moved per unit of time.	3.00
135. The student will state and apply a rule for finding the velocity of bodies moving on a straight line in any direction relative to each other and to oneself.	3.30
136. The student will describe changes in position of bodies relative to himself and to that of another observer.	1.70
137. Given a bar graph, the student will construct a frequency distribution.	2.00
138. Given bar graphs and data from his own experiments, the student will construct a reasonable prediction.	1.60
139. The student will identify and name points on a two or three dimensional graph in a conventional manner.	1.70
140. The student will construct a histogram from a table of frequencies. The histogram must include a title, labels, and scales for both axes, and the zero point must be shown on the ordinate scale.	1.50
141. Given a point graph, the student will demonstrate a procedure for extrapolating to find unmeasured values.	2.20
142. The student will order a set of predictions he has made using a point graph from greatest confidence to least confidence.	2.40
143. Given a point graph, the student will demonstrate a procedure for interpolating to find unmeasured values.	2.30
144. The student will construct a point graph given a table of data involving two variables. The graph will include a title, labels, and scales for both axes, and a smooth curve if there appears to be a trend in the data. The independent variable must be on the X axis and the dependent variable on the Y axis.	2.44

Objective	Mean Rating by Evaluators
145. The student will construct a diagram illustrating how convex lenses produce enlarged images.	3.30
146. The student will construct and demonstrate a test for determining the relative viscosity of several different liquids.	2.70
147. The student will construct a diagram of the O_2-CO_2 cycle which will include plants, animals, and decomposers as well as physical elements.	2.80
148. The student will request materials and demonstrate a procedure for making an electrical cell.	3.20
149. The student will describe the conditions necessary for the production of sound.	3.20
150. The student will name at least two ways in which each macroscopic organism in the school terrarium and aquarium changes the environment and at least one organism which the changes affect.	2.60
151. The student will name the color which will be produced when any two different color pigments are mixed.	3.20
152. The student will name three physical environmental factors which affect the germination rate of most seeds.	2.40
153. Given a list of terms, the student will identify factors which would normally tend to increase a population at least temporarily.	2.60
154. Given a number of sets of specimens, pictures, or diagrams, the student will identify the sets with most and least variability.	2.40
155. The student will demonstrate the solutions to simple ratio and proportion problems dealing with physical and biological phenomena.	2.40
156. Given a list of mathematical expressions, the student will identify those that are or may be expressed as ratios.	3.00

Objective	Mean Rating by Evaluators
157. Given a group of minerals, the student will demonstrate a method for determining the relative hardness of each.	2.90
158. The student will name three general characteristics that may be used to identify crystals.	3.20
159. Given a collection of materials, some of which contains starch and some which do not, the student will request appropriate materials and distinguish between those which contain starch and those that do not.	3.20
160. Given a list of terms, the student will identify 90 percent of those factors which directly influence the rate of soil erosion by water.	3.20
161. Given diagrams of regular polygons, the student will identify and name the following: triangle, square, pentagon, hexagon, octagon, and decagon.	2.70
162. Given a narrative account of the weather for a period of days or from observing the weather for a period of days, the student will construct a record of weather conditions utilizing a chart and standard symbols.	2.60
163. The student will demonstrate the use of a wet bulb-dry bulb hydrometer and chart for determining relative humidity.	3.00
164. Given an unlabeled diagram and a list of terms, the student will construct a diagram of the life cycle of a flowering plant.	3.20
165. Given appropriate data, the student will construct an inference about the relationship between temperature and soluability of a solid in a liquid and also the temperature and the solubility of a gas in a liquid.	3.20
166. The student will request appropriate materia s and equipment and demonstrate a procedure for determining true north.	3.20
167. Given a contour map, the student will identify and name contour lines and elevations.	3.20

Objective	Mean Rating by Evaluators
168. Given two dimensional projections, the student will identify the three dimensional object used to produce the projections.	2.80
169. Given a diagram of a beam of light incident on a plane mirror, the student will construct a diagram of the reflected beam.	3.30
170. Given a mixture of solids and/or liquids, the student will demonstrate procedures for separating the components of the mixture and for determining the volume and mass of the components.	3.00
171. Given a field situation or pictures, the student will describe the numbers of living things found in a given area and the observed frequency of various characteristics.	2.60
172. Given two or more colliding objects, the student will describe the observed changes in terms of speed, weight, and distances moved.	3.30
173. The student will describe a sequence of procedures for testing for conditions that effect plant growth.	2.20
174. The student will describe the direction of motion and the rate of change of the motion of plants, parts of plants, animals, or parts of animals which respond to a given stimulus.	2.80